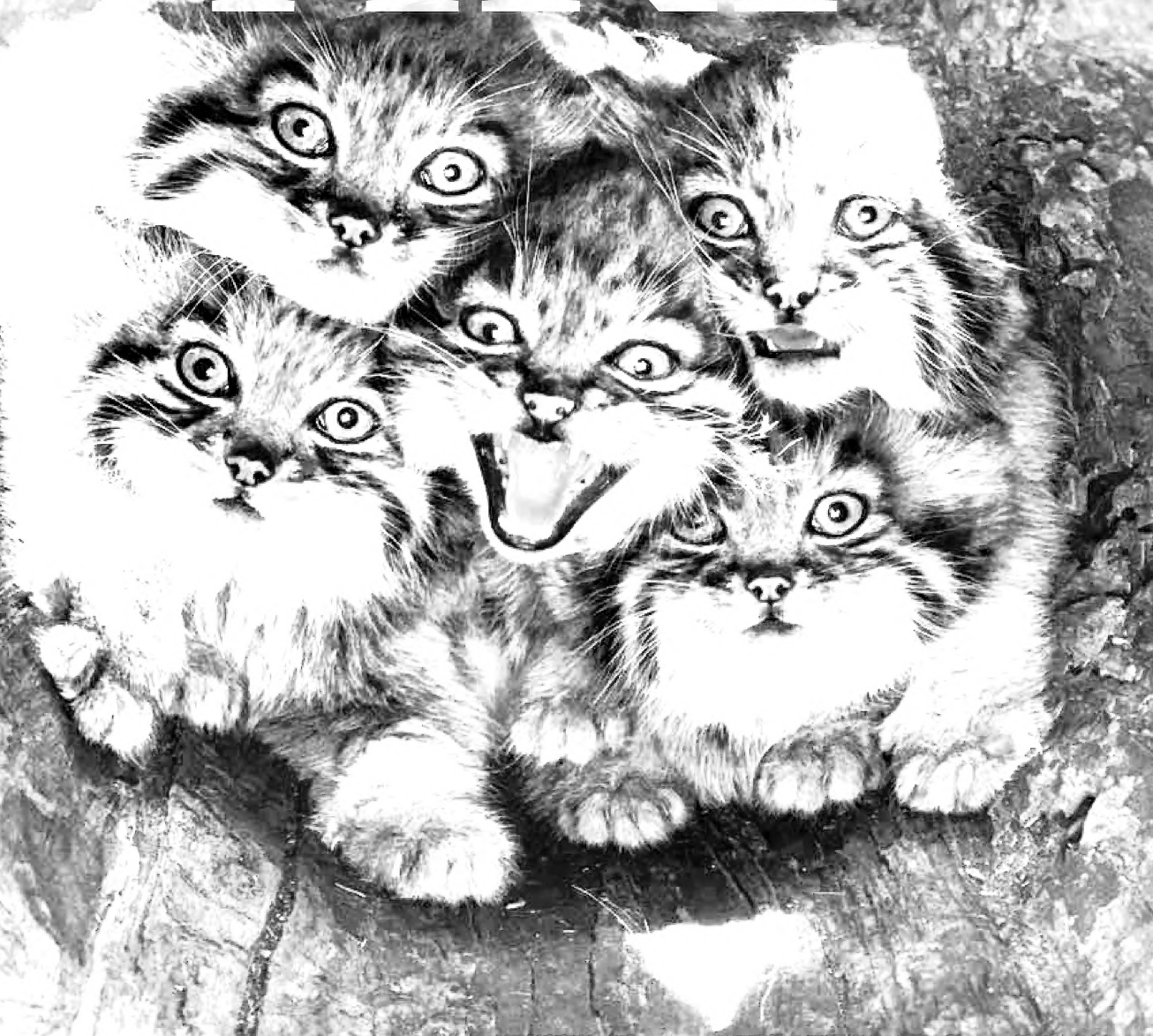


The Journal of the American Association of Zoo Keepers, Inc.

AAZK

Animal Keepers' Forum



December 2019, Volume 46, No. 12



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The American Association of Zoo Keepers, Inc. exists to advance excellence in the animal keeping profession, foster effective communication beneficial to animal care, support deserving conservation projects, and promote the preservation of our natural resources and animal life.

ABOUT THE COVER

This month's cover photo come to us from Grace Mitchell of Miller Park Zoo and features a litter of Pallas' Cats (*Otocolobus manul*). Last year Miller Park Zoo in Bloomington, Illinois imported a male Pallas' Cat from the Czech Republic giving the species a new line of genetics in the United States. On March 26, 2019 Miller Park Zoo had five Pallas' cats born, three male and two female, to a female named Nozomi and the newly imported male named Misha. These are the first Pallas' cats born at the zoo and the only Pallas' cats born in the United States this year.

The Pallas' cat is native to Central Asia. Adapted to a cold environment, they are often found in rocky, grassland or shrubland steppes at high elevations. A major part of their diet in the wild is pika along with other small rodents, birds and insects. They will chase their prey but are known to be exceptionally good at ambush hunting. Females can have up to eight kittens after a gestation of 66-75 days, becoming sexually mature around 12 months. The wild population is estimated to be around 15,000 mature individuals but decreasing. They have been Near Threatened since 2002 due in part to habitat destruction and fragmentation as a result of farming and mining.

Articles sent to *Animal Keepers' Forum* will be reviewed by the editorial staff for publication. Articles of a research or technical nature will be submitted to one or more of the zoo professionals who serve as referees for AKF. No commitment is made to the author, but an effort will be made to publish articles as soon as possible. Lengthy articles may be separated into monthly installments at the discretion of the Editor. The Editor reserves the right to edit material without consultation unless approval is requested in writing by the author. Materials submitted will not be returned unless accompanied by a stamped, self-addressed, appropriately-sized envelope. Telephone, fax or e-mail contributions of late-breaking news or last-minute insertions are accepted as space allows. Phone (330) 483-1104; FAX (330) 483-1444; e-mail is shane.good@aazk.org. If you have questions about submission guidelines, please contact the Editor. Submission guidelines are also found at: aazk.org/akf-submission-guidelines/.

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*Happy holidays
and thank you for all
that you do!*

The holiday season can be a stressful time for a lot of people and animal care professionals are no exception. Starting as far back as October, keepers often work extended hours due to events related to Halloween. These hours can then extend into November and December for “zoo lights” or other holiday-themed evening events. The addition of uncharacteristically busy days as schools and other businesses close at the end of the year can add to the strain. It is a bit like working in retail, but if the store had live bears in it.

Long hours at work are compounded by the addition of extra work outside of the zoo world. Whether it be more hours at a second job or spending time with family and friends, it’s very easy for keepers to burn the wick at both ends during this time of year. So make sure that you take care of yourselves and take the time to appreciate all of the festivities.

I also want to encourage our members to make sure that their coworkers are enjoying the season as well. All of us know that a career with animals involves working holidays and many keepers are not lucky enough to live close to family or can’t take the time off to travel home. So consider bringing the “work family” together! Gathering at somebody’s house for Thanksgiving, holding a potluck while you all work on a holiday, or forming your own traditions are all great ways to come together and ensure that everybody has a happy, fun, and enjoyable holiday season.

So from one long-hour having, holiday working, and animal-loving professional to another, Happy holidays and thank you for all that you do!

Cheers,

Paul
Paul.Brandenburger@AAZK.org

COMING EVENTS

Post upcoming events here!
e-mail shane.good@aazk.org

January 8-11, 2020
15th North American Crane Workshop
Lubbock, TX
For more information go to:
nacwg.org/workshop15.html

January 14-16, 2020
5th Annual Animal Training Workshop
San Antonio, TX
Hosted by San Antonio Zoo
For more information go to:
sazoo.org/trainingworkshop/

February 26-29, 2020
The International Association of Avian Trainers 28th Annual INTERNATIONAL CONFERENCE
Punta Cana, Dominican Republic
For more information go to:
iaate.org/iaate-conference/2020-conference

March 4-7, 2020
Venom Week 2020
Gainesville, FL
Hosted by The North American Society of Toxicology
For more information go to:
reg.conferences.dce.ufl.edu/VENOM/1566

March 29 - April 3, 2020
Animal Behavior Management Alliance (ABMA) Annual Conference
Beekse Bergen, the Netherlands
Hosted by Safaripark Beekse Bergen
For more information go to:
theabma.org/abma-annual-conference/

April 4-9, 2020
AZA Mid-Year Meeting
Palm Springs, CA
Hosted by The Living Desert Zoo and Gardens.
For more information go to:
aza.org/conferences-meetings

June 8-12, 2020
Level Up: Zoo Animal Behavior Workshop
West Palm Beach, FL
Hosted by Palm Beach Zoo and Conservation Society
For more information go to:
www.palmbeachzoo.org/new-level-up-animal-training-workshop

June 22-26, 2020
Zoos and Aquariums Committing to Conservation
Salt Lake City, UT
Hosted by Utah's Hogle Zoo and Tracy Aviary
For more information go to:
zaccconference.com/

September 13-17, 2020
AZA Annual Conference
Columbus, OH
Hosted by the Columbus Zoo and Aquarium
For more information go to:
aza.org/conferences-meetings

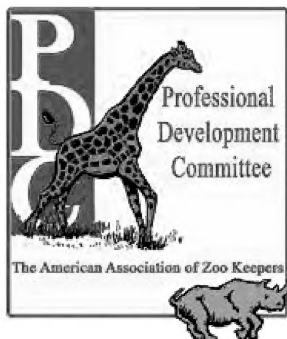


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AAZK Professional Development Committee FINAL CALL for Topical Workshop Applications for the 2020 AAZK National Conference

**46th Annual AAZK National Conference
Los Angeles, California**

August 30 – September 3, 2020

Conference Theme: “Lights, Camera... Take Action!”

The AAZK Professional Development Team is pleased to announce the FINAL call for Topical Workshops for the 2020 AAZK National Conference hosted by the Los Angeles Chapter of AAZK.

Deadline for Submission of Abstracts for Workshops: January 15, 2020

Authors will be notified regarding acceptance no later than February 15, 2020.

Workshops Format

Workshop subjects should be in-depth explorations of animal health, animal management, taxa-specific husbandry, conservation, and keeper professional development. Workshops should be two hours in length. Subjects that require more than two hours should be submitted as “Part One” and “Part Two”. Abstracts should be no more than 250 words and should focus on the main theme of the Workshop.

Open Topical Workshops

The Open Workshop format will offer unlimited attendance (based on the capacity of the ballroom) and will be best suited for lecture-based workshops with a Q & A session at the end.

Limited Topical Workshops

Held in limited capacity breakout rooms, this format is best suited for small group interactive workshops and will have a cap on the number of participants.

How to Submit Your Abstract for Consideration:

- Follow this link to fill out our Google Form Application: <https://bit.ly/2NdWYII>

You may also e-mail PDC@aazk.org for a direct link to the Google Form, or visit the conference website for more information at <https://www.aazk2020.org/>

Any questions should be directed to PDC@aazk.org with ATTN: Topical Workshop as part of the e-mail subject.

Overcoming the Challenges of Breeding Wrinkled Hornbills in a Northern Climate

Tiffany Jones

Zookeeper - Indonesian Rainforest
Fort Wayne Children's Zoo

There are thousands of bird species in the world. Many have unique breeding behaviors, nesting processes, plumage, and vocalizations. One species of bird in particular, the wrinkled hornbill (*Aceros corrugatus*), has always caught my eye and been a fascinating species. Perhaps it is their beautiful bright colors, large beaks, casques, or distinct

behaviors, but even more intriguing is their nesting process. I have been waiting years to experience this process with the pair of Wrinkled Hornbills that call the Fort Wayne Children's Zoo (FWCZ) home. In the summer of 2017, they granted me my wish, but they did not make the process easy.

During the nesting process, the female wrinkled hornbill will seal herself inside of a hollow tree. She can use a variety of materials to create the seal such as food, leaves, and even her own feces. Once sealed inside, she may not emerge for another three to four months. While the female has the important job of sealing the entrance to the nest, incubating the

Nuri at 9-months-old and first time in exhibit





Nuri's first day out of the nest box at 3-months-old.

eggs, and raising the chicks, the male has the job of feeding his family.

The pair of wrinkled hornbills at the FWCZ started exhibiting nesting behaviors in July of 2017. Nesting season for this species typically begins in February; however due to the northern climate, they are housed inside without access to a nest box in the winter months. This has shifted the timetable on their nesting season which typically starts in July for this pair. The hornbills are moved to their outdoor exhibit in May where there is access to the nest box. On July 16 of last year, the female hornbill stopped coming out of the nesting box. She had been working on sealing the entrance to the nest box for several weeks but was still going in and out. The fact that they started the process late should not have been an issue, but the FWCZ is located in Indiana. Indiana starts getting into the winter season in October. Since Wrinkled Hornbills are rainforest birds, temperatures in the low 40's and 30's are not ideal for them, especially if there is a young chick. Once we heard chick vocalizations, the planning process started in order to keep them safe for the upcoming colder temperatures.

August through the beginning of October did not have many changes. The chick's vocalizations were louder every week. We had luck on our side since the temperatures did not get cold until the middle of October. Usually we would bring our pair of wrinkled hornbills inside for the winter at the beginning

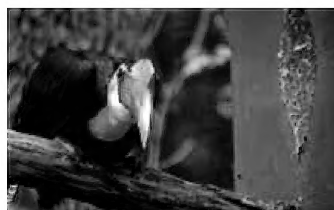


Nuri at 9-months-old and first time in exhibit.

of October or even earlier. Since we were closely monitoring temperatures, especially overnight, we provided tarps, to serve as a wind break, and a heat lamp in hopes that it would be enough to keep the male warm once temperatures started to dip in mid-October. We were able to comfortably leave the hornbills in their exhibit until October 25. At this point, it was time for us to execute our next step of the plan; it was time to relocate all of the birds inside to their accustomed winter holding area.

Before we could move the hornbills and the nest box inside, our first challenge was to remove the mesh from their indoor enclosure in order for the nest box to fit through the door. We had other available enclosures where the nest box readily fit through the doorways, but it was suggested to utilize a space that the birds were already familiar with. After that was completed, we gathered all of our materials, tools, and people to bring the nest box inside. First, the male was caught and placed in a crate in order to keep his stress levels down. A plywood board was then placed over the entrance to the nest box to keep the female and chick safe inside while moving. This step was more difficult than we had anticipated. The female started becoming defensive and continually aggressed towards the board when we were trying to attach it. Both female and chick calmed down after a few minutes.

At this point, we had all of the equipment and staff ready to carry the nest box inside safely, but the most



Bayu, male, feeding female, Ayu, in nest box.



Bayu, male, feeding female, Ayu, in nest box.

challenging part was removing it from the post. The nest box was designed and constructed with the thought that it would never need to be removed. The nails attaching the nest box to the post could not be accessed. The only way for our staff to remove the nest box from the post was to twist it until it was loose enough to be taken down. Please note that the female and chick were still inside of the nest box during the entire process. Looking back, this was the most stressful part of the move for me. We were tilting the nest box while it was six feet up and our ability for at least six people to keep it level was not easy. Eventually, we were able to safely remove the nest box from the post and set it on the ground. It took eight people to carry the box which weighed around 200 pounds.

Once we secured the ratchet straps to keep the nest box intact during the move, we started carrying it to their winter enclosure. After the board was placed over the entrance, we did not hear any movement or vocalizations from the female or the chick during the rest of the move. Once inside, the nest box was set on a bench made specifically for this event and the enclosure mesh reattached. We were unsure if the birds would emerge right away due to the stress of moving, but after the plywood board was removed, both birds remained inside. Our male was released into the enclosure shortly after that. He appeared to recognize the nest box and after approximately twenty minutes he was seen offering food to the female



Removing the nest box to relocate inside. Female and chick are still inside.



and chick. We could all breathe a sigh of relief that the difficult part of was over.

Several weeks went by and there was no indication that the female and chick were close to emerging from the nest box, despite their anticipated emergence time passing. We were starting to observe uncharacteristic behaviors in the female in the middle of November. AZA colleagues were contacted and the consensus was that the female wanted out and was unable to break the seal. She seemed to be exhibiting stressful behavior. On day 123, exactly four months since the female sealed herself inside, we were able to break the seal and open the entrance hole so that they could emerge. After only a


few minutes, the female exited and flew up to a higher perch. She looked to be in good condition. The chick emerged much later, but was very curious of its new surroundings. The male and female encouraged the chick through vocalizations. The chick came out and immediately fell on the ground not knowing how to fly yet. After an hour of hopping on the ground, the chick mustered up the courage to fly onto a lower perch. It took much effort to reach that perch, but once it did, the male was trying to feed it right away. They all seemed healthy and relieved to be out of that box!

Still not in the clear yet, an unanticipated challenge occurred later

that same day when the male started acting aggressive towards the female. At first, it seemed like normal copulation, but as the day progressed so did his aggression. We decided to separate him from the female and chick because he kept continually grabbing the female by the neck. This is not a normal behavior and it was recommended to separate them immediately. Since the separation, all three have been exhibiting normal behaviors. The chick was confirmed to be a female on December 12, 2017.

The chick and female remained together until early March 2018. At that point, they were separated due to increased aggression towards each other. Once the chick was separated from the female, our male was exhibiting interest in the female again. He was attempting to feed her through the enclosure mesh several times a day. Our initial plan was to mix them together once they were moved to their exhibit. Due to the interactions being positive between male and female, we mixed them together in their winter enclosure. There were no aggression issues and these hornbills have been peacefully residing together since.

Due to the timing of other animal transactions, we were lucky enough to highlight our wrinkled hornbill chick to the guests for the 2018 season. Many guests were able to learn about the nesting process of wrinkled hornbills the previous summer and were excited to see the successful chick that came from that process. The staff is hoping our adult pair will attempt to nest this summer and the process will start over.

This was an exciting and stressful process that would not have been possible without good communication, a great team of keepers and staff, and all of the advice and encouragement from AZA colleagues. The team effort is what made this hornbill story a success! 

Education for All: Supplying the Abidjan Zoo with essential educational supplies



School Children IVC



Abidjan Zoo Entrance with school children



Author and Abidjan Zoo Director

In 2011, the Ivory Coast was devastated by the country's second civil war. During the fighting, the sole zoo in the heart of the nation's capital, Abidjan, was greatly affected, leading to many animals dying of starvation, and several buildings, including the education department, destroyed or looted. Education resources such as computers, paper, and books were either stolen or burned. This made the recovery devastating not only economically, but also academically.

One million students pass through the Abidjan Zoo annually, learning the importance of animal conservation and how local species of plants and animals play a role in their region. In 2014, I started an annual golf fundraising tournament to help raise funds for local and global animal projects called Golf for Wildlife. In 2015, I teamed up with the American Association of Zoo Keepers' San Diego Chapter to host the second annual Golf for Wildlife event

where funds raised would benefit the education department of the Abidjan Zoo. Recently a new education building was restored, but is still drastically far behind in recouping the necessary supplies for its youth's enrichment needs. Funds raised through Golf for Wildlife will first, help purchase the needed supplies and second, visiting students to the zoo from all around the country will learn about animals found in their country.

Over the past several years, the San Diego Zoo's Reptile Department has sponsored the work in West Africa of Dr. Matt Shirley, a Ph.D. student from the University of Florida, Gainesville. Dr. Shirley discovered a new species of crocodile, the West African slender-snouted crocodile (*Mecistops cataphractus*), which he later determined is on the verge of extinction. For over 150 years, this species was thought to be the same species in

central and western Africa. His research has separated the slender-snouted crocodile into the western and central slender-snouted crocodile species. His research and study of the region led him to the only zoo in the Ivory Coast, the Abidjan Zoo, where the largest number of adult West African slender-snouted are housed in zoos in the world.

The staff at the Abidjan Zoo were not well trained on the proper care, husbandry, diet, and safe handling of these crocodiles. This can be dangerous to the crocodiles and to the lives of the staff. With this notion in place, and Matt Shirley's ties with the St. Augustine Zoo, the director of the Abidjan Zoo received a grant to attend the Crocodilian Biology and Professional Management course hosted by the St. Augustine Alligator Farm and Zoological Park in St. Augustine, Florida. The director of the Abidjan Zoo, whom I would later come to know as Digbe, had never left



Education Supplies



Digbe at AZA Crocodillian School



Slender-snouted Crocodile exhibit in IVC

the Ivory Coast. As a former colony of France, the official language of the Ivory Coast is French. Digbe knew very little English and as a fluent French-speaking reptile keeper, the San Diego Zoo saw a great opportunity for me to travel to the St. Augustine Zoo and help translate the course for Digbe. This was an once-in-a-lifetime opportunity to learn from some of the country's premier crocodilian experts, and this course offered the best chance to help the director of the Abidjan Zoo gain a better understanding of crocodiles and thus share it with his staff.

After the professional course, years of communication with Digbe and members of the Abidjan Zoo, I met Sophie Decelle. Sophie is a wildlife conservationist who is passionate about wildlife and their habitat. In 2004, she founded the "Association du Calao Asbl" (referred to as Calao) which focuses many of its resources in Kenya. After the second civil war, the association's focus turned to the Ivory Coast, particularly

the Abidjan Zoo where one in four animals had starved to death. She was able to obtain 1.1 million euros through private donors and sponsorship to help aid the zoo. The goal of Calao is to create an organization, which would connect all the zoos in Western Africa and provide a united voice to local communities on conservation issues and projects. With Sophie's help, the help of Calao's Education Coordinator Oumar Kante, and after many years of waiting, the education supplies safely reached the Abidjan Zoo's Education Department.

Calao is not a big association but it has sustainable projects that are important locally to the community of Abidjan and

ITEMS PURCHASED FOR ABIDJAN ZOO'S EDUCATION DEPARTMENT.	QUANTITY
70cm x 100 cm Conference Whiteboard	02
Magnetic 90cm x 120 cm Whiteboard	01
Blue erasable marker	20
Black erasable marker	20
Red erasable marker	10
Green dry erase marker	10
HB pencil graphic	36
Scissors w/ plastic handle (soft)	02
Magnets round 12mm (set of 10)	04
Magnetic brush	02
White eraser	20
Metal Pencil Sharpener	20
Color pencils 18 cm (package of 12 pencils)	15
Color pencils 18 cm (cover of 24 crayons)	01
Chalkboard	15
Felt kids	10
Scissors plastic handle (left-handed)	10
400 blank pages for writing	01
Door clamp block	02
Ballpoint Tip Pens	50
Cardboard cutouts	50
Sitting mats	02
Dallas toilet paper (package of 10)	01
Multi-use paper roll	01
Lotus toilet paper (package of 6)	02
Book: Friendship (7 books) Collection	02
Book: Raising your child	02
Book: Prodigious Nature	05
Book: Listen to me	03
Book: Collection guide to medicinal plants (Book 2)	01
Book: History of animals (Collection of 4 books)	01
Book: History for the character (Collection of 4 books)	01
Rulers	02
Train package	05
16 GB USB key	02
Carpet	10
Hand Gel tube	06
Hand Sanitizer	02
Sony DVD player	01
Container for pencils	02

the Abidjan Zoo. The list of people I would like to thank is endless. If it were not for AAZK SD, San Diego Zoo Global and the Herpetology team, Sophie and Oumar of Calao and donors and golf participants of Golf for Wildlife, none of this would be possible. Projects and success stories like this show that it does not matter where you live or how much money you raise, anything can make a difference. Inspiring our next generation of scientists, especially in areas like West Africa, can be the difference between life or death for many plant and animal species of the world. 🐢

Changes in Flamingo Foot Condition Following Substrate Changes in Holding Areas

*Joy Kotheimer, Zookeeper IV Shores Region
Columbus Zoo and Aquarium
Powell, Ohio*

*Ian M. Hamilton, Associate Professor
Department of Evolution, Ecology, and Organismal Biology
Department of Mathematics
The Ohio State University, Columbus, OH, USA*

Introduction

Foot lesions are common concerns in management of avian species such as birds of prey, waterfowl, and shorebirds, especially when birds are housed in areas with non-natural substrates for a prolonged period of time (Rodriguez-Lainz et al., 1997; Erlacher-Reid et al., 2012). Ideal husbandry aims to prevent foot lesions by mitigating the flooring and substrates to meet the specific needs of its occupants, as open

lesions can allow bacteria to enter the foot and cause infection locally or even advance to joints and organs (Phelan et al., 1990; Wyss et al., 2015). This can be particularly important for younger birds, as these lesions can become a chronic issue into adulthood (Phelan et al., 1990). Monitoring foot condition can provide an assessment of effects of environmental conditions on individuals' foot health for both acute issues (as fissures can form quickly)

and more complex issues (lameness/ abnormal weight bearing leading to formation of nodular lesion of increasing severity). For example, inflammation of nodules and progression of severity indicates which leg is taking the majority of duration bearing weight comparatively (Bapodra-Villaverde, 2018). Association of changes in foot condition with substrate changes can provide insight into the causes of lesions and how management of substrate can affect foot health of birds residing in holding areas.



At the Columbus Zoo and Aquarium, animal care staff currently use presence and severity of foot lesions to aid consideration of medical treatment for several flamingos in our flock, as these traits are associated with their chronic joint pain and inflammation. The individuals hatched and raised at our facility experience a temperate climate in Ohio, which predisposes them for occurrences of fissures (Nielsen et al., 2012).

Types of mats used in the holding area include: Dri-Dek® mats, artificial turf mats, VinLoop™ vinyl mats (similar to Nomad™ mats, but thicker and sturdier) and rubber anti-fatigue mats (approximately 2 cm thick, solid,

non-slip rubber with regularly spaced holes approximately 2.5 cm diameter for drainage). Criteria for selection of mats includes whether the mats submerge in water and provide a non-slippery surface on which flamingos can stand or walk and is durable for daily cleaning.

The objective of this study is to assess the effectiveness of substrate changes in the holding areas over time on the occurrence of foot lesions in a flock of Caribbean flamingos (*Phoenicopterus ruber ruber*) at the Columbus Zoo and Aquarium (CZA). While the exhibit features remained fairly constant during this study, the holding area mats and substrates were changed over time with the intent to improve foot conditions by minimizing occurrence and severity of foot lesions, especially during the winter months when the flock has less exposure to natural substrates. Major changes included: 1) six artificial turf mats (total approximately 5 m²) that were donated by The Ohio State University and added to concrete-floored holding room Dri-Dek® mats coverage 2) a 26.8 m² greenhouse with a mixture of river rock, sand, and topsoil floor extended winter outdoor holding area availability and 3) VinLoop™ vinyl mats (12.3 m²) and anti-fatigue rubber matting (13.4 m²) that were added to concrete-floored holding room mat coverage.

Two questions were used to assess changes associated with each of the four types of foot lesions.

First, does the total number of all lesions change and differ between sexes and between birds raised at our facility (CZA) versus another facility? Second, does the most severe instance of each lesion differ for individuals with at least one occurrence of the lesion and B) does the most severe level differ?

Methods

Flamingo foot lesion categorizations from Nielsen et al. (2012) were used; these consist of fissures, nodular lesions (bubbles), hyperkeratosis (flattening), and papillomatous growths (Fig. 1). Lesion severity was ranked as minor or severe using objective criteria listed on Table 1. Weight and plantar foot pictures were obtained from each individual at least once annually during physicals and during any additional opportunistic inspections or medical procedures, starting in 2011. Three periods of time were designated for comparison based on the major changes in substrates available to the flamingos while in holding areas. Period 1 (January 2011 to December 2015): six artificial turf mats added to replace holding room Dri-Dek® mats coverage. Period 2 (January 2016 to October 2016): addition of greenhouse in addition to changes from Period 1. Period 3 (November 2016 to March 2017): addition of VinLoop™ vinyl mats and anti-fatigue rubber matting to holding room mat coverage, primarily replacing Dri-Dek® mats, and maintaining changes from Periods 1 and 2.

Lesion Type	Severity
Hyperkeratosis	1= epithelium flattened
	2 = marked overgrowth
Fissures	1= <2mm
	2= >2mm
Nodules	1= closed nodule
	2= open, exposed tissue
Papillomatous growths	1= small finger-like proliferations
	2= clusters of proliferations

Table 1. Foot Lesion Classification and associated measures of severity from Nielsen et al. (2010).

Statistical Analysis

Effects on the counts of lesions per foot and the most severe instance of each lesion per foot were analyzed using Generalized Estimating Equations (GEE) implemented in SPSS (IBM Corp., Version 24). Tests on counts of lesions used a Poisson distribution and log link function. Tests on whether individuals had a severe lesion if exhibiting any degree of that lesion type used a binomial model and logit link function. Fixed factors in all models were time period (1-3), sex (male/female), hatching location (CZA/other), and foot (right/left). Foot within bird was a repeated factor in all models. Individual bird was included as a random effect and foot and date of collection were repeated effects in the models.

Results

Nodules: The total number of nodules increased between Period 1 and later periods (Table 2; Table 3). In addition, females had more total nodules than males (means (95% CI); females: 1.36 (1.15-0.61; males: 0.79 (0.57-1.11); GEE: Wald $\chi^2=8.141$, df=1, $p<0.004$). There was a significant interaction between sex and time period, with females having more total nodules than males in Period 1, but slightly fewer total nodules than males in later periods (Table 2). There were no severe nodules during the first time period, so we used only Periods 2 (2011-2015) and 3 (2016-2017) in our analyses. For females, probability of a severe nodule declined from Period 2 to Period 3, while the males showed the opposite pattern (Table 3; sex and time period: Wald $\chi^2=13.262$, df=1, $p<0.001$).

Figure 1. Examples of the four types of flamingo foot lesions categorized by Nielsen et al. (2012): a) hyperkeratosis, b) fissure, c) nodule, d) papillomatous growth.

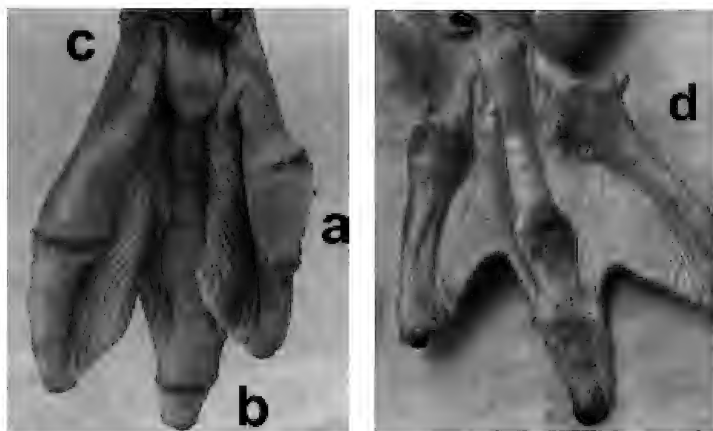


Table 2. Comparison of total counts of lesion types compared between time periods. Within a lesion type, values followed by the same letter are not significantly different from one another.

Lesion Type	Sex	Period	Mean	95% Wald Confidence Interval	
				Lower	Upper
Nodules ¹	Females	1 (2010-2011)	0.52a	0.34	0.81
		2 (2011-2015)	2.11b,c	1.88	2.36
		3 (2016-2017)	2.31b	2.01	2.65
	Males	1 (2010-2011)	0.08d	0.03	0.21
		2 (2011-2015)	2.48c,e	2.28	2.70
		3 (2016-2017)	2.67e	2.32	3.06
Hyperkeratosis ²	Both	1 (2010-2011)	1.68a	1.38	2.05
		2 (2011-2015)	3.67b	3.53	3.82
		3 (2016-2017)	4.07c	3.92	4.22
Fissures ³	Females	1 (2010-2011)	2.24a,b	1.84	2.74
		2 (2011-2015)	2.15a,b	1.82	2.55
		3 (2016-2017)	2.35a,b	1.87	2.96
	Males	1 (2010-2011)	1.67a	1.23	2.28
		2 (2011-2015)	2.25b	1.90	2.66
		3 (2016-2017)	2.12a,b	1.72	2.61
Papillomatous Growths ⁴	Both	1 (2010-2011)	0.34a	0.20	0.59
		2 (2011-2015)	0.32a	0.23	0.45
		3 (2016-2017)	0.14b	0.07	0.30

¹Generalized Estimating Equation (GEE)*; sex: Wald $\chi^2 = 8.141$, $df = 1$, $p = 0.004$; period: Wald $\chi^2 = 70.588$, $df = 2$, $p < 0.001$; period x sex: Wald $\chi^2 = 15.039$, $df = 2$, $p = 0.001$; all other effects not significant

²GEE; period: Wald $\chi^2 = 77.785$, $df = 2$, $p < 0.001$; all other effects not significant

³GEE; sex x period: Wald $\chi^2 = 8.326$, $df = 2$, $p = 0.016$; hatching location: Wald $\chi^2 = 6.728$, $df = 1$, $p = 0.009$; all other effects not significant

⁴GEE; period: Wald $\chi^2 = 8.516$, $df = 2$, $p = 0.014$; all other effects not significant

*Generalized Estimating Equation using a Poisson distribution and log-link

Hyperkeratosis: There was a significant increase in the total number of occurrences of hyperkeratosis (flattening epithelium) over time (Table 2). There was an increased likelihood of more severe flattening between Period 2 (2011-2015) to 3 (Jan-Oct 2016) (Table 3; Wald $\chi^2 = 9.601$, $df = 1$, $p < 0.002$).

Fissures: Males had more fissures in Period 2 (2011-2015) than Period 1 (2010-2011), and females did not differ with time period (Table 2). Flamingos hatched at CZA were more likely to have fissures than were birds hatched at other facilities for total number of all severities (Wald $\chi^2 = 6.73$, $df = 1$, $p = 0.009$).

The probability of an individual having severe fissures was lower in Period 3 (2016-2017) compared to Period 2 (2011-2015) (Wald $\chi^2 = 8.253$, $df = 1$, $p = 0.004$) (Table 3).

Papillomatous growths: In Period 3 (2016-2017), there were significantly fewer papillomatous growths per individual (total number of all severities) compared to during Period 1 (2010-2011) and 2 (2011-2015) (Wald $\chi^2 = 8.51$, $df = 2$, $p = 0.014$) (Table 2). The model for examining severe papillomatous growth lesions did not converge.

Discussion

After half of the holding room's Dri-Dek® mats were replaced with VinLoop™ vinyl mats in 2016 we observed a trend of regressing fissures, but for individuals with nodules (bumbles) a possible progression of severity. While we increased coverage of mats with softer cushioning (in order to decrease occurrences of lesions), this type of substrate alone might not be most effective for birds with existing

bumbles. The uniform softness might not distribute pressure well all around the entire foot, but instead focus the weight-bearing portion on the nodule, which could increase inflammation and degrade the epidermis. This initiated discussion of managing foot health of the flock while attending to specific needs of individuals, which can be challenging for many facilities as flock size and species present in areas vary.

Striving to meet ideal foot conditions of flamingos through changing mats and substrates of the holding areas could be compared to opening the Pandora's Box for flamingo foot care. Our results indicate that, while new mats and substrates could promote improvements of some lesions from occurring, it could also increase the likelihood of another lesion progressing. In response to these results regarding severe nodules, we covered more holding room area with thick rubber anti-fatigue mats to offer a more varied texture directed towards individuals with nodules to self-adjust their stance. This is similar to the effect of varying perch shapes and textures for perching birds, or substrates for waterfowl and poultry (Rodriguez-Lainz et al., 1997; Phelan et al., 1990; Youssef et al., 2012). Preliminary observations using cameras overnight revealed that flamingos with severe bumbles would not necessarily choose to remain in areas with mats we deemed best for their particular foot health; rather, resting areas are possibly determined more by preferred location in the room (or rather where its mate preferred). This also has an additional challenge, as individual flamingos are not faithful to staying in one area both day and night. Future studies of nodule progression could also utilize more specific measurements (i.e. the diameter of a nodule to document changes in inflammation) from images as long as a known standard measure (such as a coin) is in the image.

While there were more occurrences of hyperkeratosis over time, this type of lesion has the least amount of immediate risk for introducing bacteria into the body (no open wounds) and previous studies suggest this lesion is extremely common. For example, a comprehensive study by Nielsen et al. (2010) found 100% of 854 individuals

Table 3. Comparison of probabilities for severe occurrences of a lesion type using estimated means between Periods 2 and 3. Within a lesion type, values followed by the same letter are not significantly different from one another.

Severe Lesion Type	Period	Mean	Std. Error	95% Wald Confidence Interval	
				Lower	Upper
1Nodules (Females)	2 (2011-2015)	0.25a,c	0.053	0.160	0.360
	3 (2016-2017)	0.14b	0.033	0.080	0.220
1Nodules (Males)	2 (2011-2015)	0.2a,b	0.036	0.140	0.280
	3 (2016-2017)	0.36a,c	0.075	0.230	0.510
2Hyperkeratosis	2 (2011-2015)	0.42a	0.038	0.340	0.490
	3 (2016-2017)	0.65b	0.780	0.490	0.790
3Fissures	2 (2011-2015)	0.44a	0.035	0.380	0.510
	3 (2016-2017)	0.27b	0.043	0.190	0.360

¹Generalized Estimating Equation (GEE)*; sex x period: Wald X2 = 13.262, df = 1, p = 0.00; sex x period x hatching location: Wald X2 = 7.326, df = 1, p = 0.007; all other effects not significant

²GEE; period: Wald X2 = 9.601, df = 2, p = 0.002; all other effects not significant

³GEE; period: Wald X2 = 8.253, df = 1, p = 0.004; all other effects not significant

*Generalized Estimating Equation using a binomial distribution with logit-link

had the presence of hyperkeratosis, with representation of four flamingo species. Interestingly, left versus right foot was a significant effect in the test model of severe hyperkeratosis, which might indicate some individuals have a preferred foot on which to stand. A study by Anderson and Williams (2010) found Caribbean flamingos tend to have a preference for standing on one foot over both at rest, and those birds tend to trade off between right and left feet. We have not conducted a foot preference study in our flock, but personal observations of individuals with chronic medical issues (namely ankle injuries), as expected, often choose to stand on their uninjured leg, which tends to increase chances of lesions occurring.

This study was an opportunistic use of plantar foot picture data collected since 2010; therefore, there was no control group for comparison—all the individuals in the flock experienced the same conditions. While the effects of time or other variables that were not included in this study could contribute to the results, the overall nutrition and husbandry practices remained unchanged except for holding room

substrate changes through different mats and expansion of natural substrate access with the greenhouse.

Limitations of data collection for this study include differences between individuals in ability to safely obtain plantar foot pictures on a regular basis; for example, hand-raised flamingos are often less stressed and less prone to injury during capture and restraint than flamingo-raised individuals. In addition, the few flamingos with joint issues received more frequent assessment of foot lesion progression in conjunction with observations of lameness to aid the veterinary staff's course of treatment. Despite these limitations, this study revealed trends in foot health of our flock and gives support for which types of mats and substrates on which to focus for future budgeting and improvements for the holding areas. Establishing a regular documentation of foot conditions by plantar foot pictures can provide valuable supportive data for managing changes in substrates of exhibits or holding areas as well as offer insight for medical treatment of individuals. Less invasive techniques, such as providing a clear acrylic stand

with a camera underneath to provide unrestrained (whether opportunistically or as a voluntary-trained behavior) plantar foot pictures could improve ability to regularly inspect foot health if images of sufficiently high quality from a large number of known individuals can be obtained.

Mitigating deterioration of foot health using environmental substrates is an important focus in flamingo husbandry. We found a decrease in fissures after providing VinLoop™ vinyl mats and regular access to sandy substrate greenhouse during colder months, suggesting that these can improve foot health. Moving forward, we are planning additional efforts in our husbandry goals to speed up healing of fissures and nodules and therefore decrease likelihood of infectious agents entering the body through open lesions. These types of lesions tend to require the most management and possible long-term effects, and in turn, may reduce the occurrence of papillomatous growths. The added accessibility of the greenhouse in 2016-2017 for flamingos at CZA supports that exposure to sandy soil decreases the risk of papillomatous growths occurring (Nielsen et al., 2012). With insight from the husbandry manuals and current research, it is beneficial for keepers and veterinary staff to continue discussion and improvements of holding area substrates. Taking into account the needs of individuals while providing care for the entire flock can provide challenges that may seem facility-specific, but assessment of foot health and substrates can provide valuable information for any facility to increase welfare of its inhabitants.

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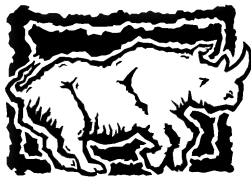
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Dominic Dongilli, AAZK Safety Committee



Introduction

The field of animal care has a long history. It is accompanied by a number of traditional practices that were established in good faith and with the available research evidence. However, without consistent reevaluation that considers updates in the field and research, these “good-faith practices” can be ineffective or even detrimental to the health and welfare of the animals under our care. Containing the spread of micro-organisms within the zoo is one such foundational practice; the most ubiquitous piece of zoo technology used to do this is... the footbath. Footbaths have long been used to prevent cross contamination and the spread of any potential pathogens amongst zoo animals and exhibits. Using them appropriately and effectively is tantamount to accomplishing this goal.

Requirements for animal health, including husbandry and cleaning, are a part of the “Animal Welfare Act” (7 U.S.C. § 2131 et seq.) and its subsequent regulations. Enforcement of these standards is administered by the U.S. Department of Agriculture’s (USDA) Animal and Plant Health Inspection Service (APHIS). All decisions regarding disease management and health and chemical use should be made in light of these regulations and under the guidance of certified animal health and safety personnel designated and trained to fulfill these roles.

Furthermore, the “Federal Insecticide, Fungicide, and Rodenticide Act” (7 U.S.C. §136 et seq. (1996)) as administered by the Environmental Protection Agency (EPA) governs the registration and labeling of substances labeled “antimicrobial pesticides,” which are “intended to disinfect, sanitize, reduce, or mitigate growth or development of microbiological organisms or protect inanimate objects, industrial processes or systems, surfaces, water, or other chemical substances from contamination, fouling, or deterioration caused by bacteria, viruses, fungi, protozoa, algae, or slime” (EPA, “Antimicrobial Pesticides” 15 November 2016, “Antimicrobial Pesticide Registration” 01 Feb 2018).

Speaking the codes of cleaning

Colloquial discussions most often use the words “clean”, “sanitize” and “disinfect” interchangeably. However, their differences are significant. Confusing their meanings when attempting to contain the spread of microorganisms is of legitimate concern and can be of serious consequence.

“Cleaning,” “sanitizing,” and “disinfecting” are accomplished by the proper use of compounds designated as “cleaners,” “sanitizers,” and “disinfectants.” Understanding the appropriate use and properties of these compounds enables animal care staff to best understand these processes.

A cleaner is a compound that physically removes organic materials or loose particles from a given surface and enables them to be washed away with water (USDA “Cleaning” 14 Sep 2017). Common cleaners include soaps and detergents. Cleaners must be physically applied and worked into a surface, often through a form of agitation, and then rinsed away with water. Application of the cleaner and subsequent rinsing with water are essential in order to complete the act of cleaning. The most common act of cleaning is washing hands with soap and water. Hands are wet, soap is applied and worked onto the surface through sufficient scrubbing, and then the suds are rinsed away.

A sanitizer is a compound that reduces the number of microorganisms present to an acceptable level as designated by a given health code regulation. The sanitizing process is often used in regards to food prep tasks or with items that will be in close contact to orifices and mucous membranes. Some chemical compounds are safe and effective for use as either a disinfectant or a sanitizer if stated on the label, which is determined by the dilution ratio of chemical compound to water. The decision to sanitize versus disinfect is often made when considering the risks posed by the targeted microorganism compared to the risk of chemical contact and toxicity as a result of the chemical's use. Since zoo keepers clean surfaces that are regularly contaminated with bodily fluids and organic waste, sanitizing is generally inappropriate.

A disinfectant is a compound that kills or destroys microorganisms present on a non-living surface. When used properly, disinfectants significantly destroy the number of microorganisms targeted. However, they do not completely eliminate the presence of these microorganisms nor do they eliminate spores (USDA “Disinfection” 14 Sep 2017). Generally speaking, porous materials cannot be properly sanitized or disinfected and the presence of organic materials inhibits the efficacy of disinfectants and sanitizers that are not also designated cleaners. As a result, one cannot disinfect or sanitize muddy boots or an animal holding space contaminated with smeared fecal matter. In order for disinfectants to be the most effective, organic material MUST be removed through the process of cleaning prior to the disinfection process (USDA “Disinfection” 14 Sep 2017).

Sterilization is the process of completely destroying all forms of biological life present (USDA “Disinfection” 14 Sep 2017). This process can be done physically or chemically with devices such as autoclaves or gas sterilizers. Sterilization is commonly used

Table: The Codes of Cleaning

Term	Definition	Example
Cleaning	Physically removes organic materials	Hand soap and water, power washer, brush
Sanitizing	Reduces the number of microorganisms present	Hand sanitizer, diluted bleach
Disinfecting	Kills or destroys microorganisms	Bleach, alcohol, hydrogen peroxide
Sterilizing	Completely destroys all forms of biological life	Autoclave (steam sterilization)

in laboratory and healthcare settings where the integrity of experimental methods or medical procedures is of paramount importance. It is not often employed in the routine husbandry and care of zoo animals.

Footbaths – Or trying to keep shoe bottoms clean

In order to safely and effectively utilize a footbath, the general process and considerations of disinfection should be followed. If all steps of the disinfection process are not given due consideration, then the process will be ineffective.

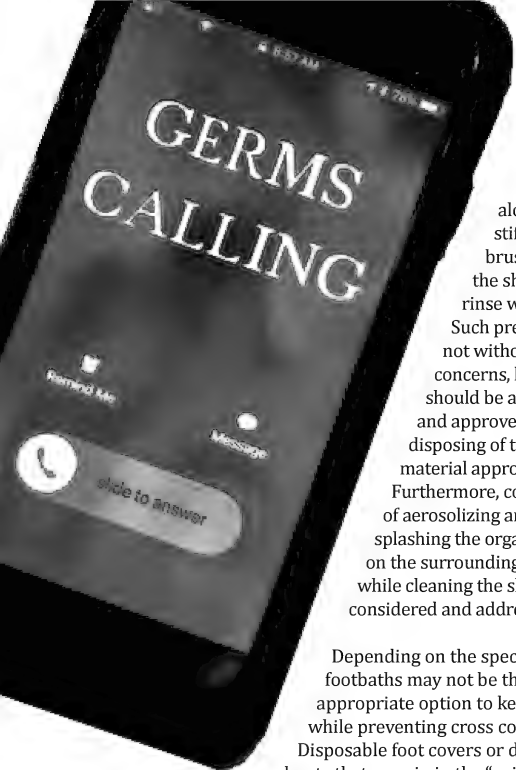
All relevant information regarding chemical disinfectants can be found on the chemical's label and SDS sheets. This information should include the disinfectant's approved spectrum, active ingredient, instructions for proper use and relevant first aid measures. This information MUST be thoroughly read and followed.

1. Starting points and materials:

The cleaning and disinfection process should always be contextualized by the relevant situation(s) being considered.

- Is there a specific micro-organism of concern or is the goal to prevent cross-contamination? There are different classes of disinfectants with different abilities to target specific micro-organisms.
- What are the relevant species of animals and their zoonotic risk? Do they have any specific chemical or sensory sensitivities?
- Is a footbath the most appropriate option? Are disposable shoe covers or individual pairs of shoes that can only be stored and worn in designated areas a safer and more effective option?

As discussed above, it is generally true that organic materials cannot be effectively disinfected (USDA “Disinfection” 14 Sep 2017). Some disinfectants are also labeled “cleaners” meaning they contain chemical compounds able to cut through organic material. However, the majority of disinfectants do not contain cleaning compounds, so contaminated shoes should be “prepped” for the footbath. This preparation normally includes some type of cleaning. Depending on the organic material, a dry clean may be appropriate where the material can be removed with a stiff-bristled brush. A solution of cleaner may need to be used



along with a stiff-bristled brush to clean the shoes and then rinse with water.

Such preparations are not without their own concerns, however. There should be a designated and approved process for disposing of this organic material appropriately.

Furthermore, considerations of aerosolizing and/or splashing the organic material on the surrounding environment while cleaning the shoes must be considered and addressed.

Depending on the specific concern, footbaths may not be the most appropriate option to keep shoes clean while preventing cross contamination. Disposable foot covers or designated boots that remain in the "suit-up" area of buildings could be a better option.

2. The context - what are we dealing with?

Even if a disinfectant footbath is the appropriate option, are the relevant environmental variables present to enable effective use?

- Certain disinfectants are rendered ineffectual outside of set temperature parameters. Specific formulations of water (hard vs. soft, filtered) may be required for dilution.
- What are the maintenance parameters of the chemical? Certain disinfectants can evaporate or loose effectiveness after a certain time has passed - is that maintainable in the given situation? How many times can the disinfectant solution be used? Are there indication signs of contamination or spent usage so that the footbath can be serviced as needed or does a regular schedule need to be maintained? Are there sufficient record keeping or accountability systems in place to ensure this maintenance is taking place?
- What is the required contact time of the disinfectant? A certain chemical may be extremely effective at targeting a specific micro-organism, however, it could have a lengthy contact time. Generally speaking, surfaces must remain wet/saturated with the disinfectant solution for 10 minutes or longer in order to be effective. Are zoo keeping staff standing in footbaths for the appropriate amount of time?

3. When it's all over:

Appropriate disposal is paramount to maintaining the cleanliness and integrity of the space. Appropriate disposal protocol should be listed on the disinfectant's label or SDS sheet. If the footbath is contaminated with organic material such as feces or bodily fluids such as blood, additional disposal guidelines may be applicable.

The Trifecta: "Planes, Trains & Automobiles..." also known as "Shoes, Keys & Radios"

What's on the bottom of shoes is often of utmost concern and what is commonly targeted as animal care staff move amongst different areas of the zoo. However, the bottoms of shoes are not the only objects that move amongst animal exhibits with the potential to serve as vectors of disease. What about the keys and tools and approved communication devices that travel on belts that are used in exhibits and holding spaces throughout the day?

Some institutions utilize key washes to prevent cross contamination as zoo keepers take keys on and off their belts and enter animal holding spaces throughout their day. A small bowl of disinfectant solution is placed alongside foot baths or mounted on the wall next to appropriate doorways for keys to be cleaned. All protocol for disinfection as discussed prior still apply. Further considerations include the metallic composition of keys. Make sure the disinfectants are safe for use on metal and/or do not leave significant residue on the keys that will inhibit safe padlock function.

Cleaning pieces of communication technology may be important as well. Unless zoo keepers are consistently washing hands or removing PPE such as gloves whenever answering those unplanned and unexpected radio calls, handheld radios have the potential to be extremely contaminated. Not only are these devices held on the body and close to the mouth when speaking, they are carried around from animal space to animal space. Follow the manufacturer's instructions for appropriate cleaning and select a disinfectant and subsequent application method appropriate for use on electronics.

Cellphones carried on the body, either personally owned or company provided, are also a point of consideration for cleaning and disinfection as they leave the confines of the zoo and travel into public and personal spaces. It should be noted, however, that cellphone use in the animal care setting can pose a serious safety risk. Institutional safety guidelines should be strictly adhered to at all times including the appropriate use, or rather disuse, of cellphones. The AAZK Safety Committee firmly believes in minimizing any potential distraction from the animal care work environment to minimize unnecessary safety risk.

Conclusion

There's no "one-size-fits-all" solution to managing microorganisms. Facilities should review their good-faith practices and think critically about their health and management goals. If footbaths are used to avoid cross contamination, the efficacy of the methods and the materials used should be assessed by trained animal health and safety staff members with overall goals in mind. Additional practices,

including cleaning other items beyond the bottoms of shoes, should also be considered. Finally, the facility should discuss if their footbath and microorganism management practices should vary between species or exhibits. There is no simple answer for microorganism management, and every facility should be thoughtful and flexible when implementing footbaths and other similar protocols. 🐾

References and Useful Links

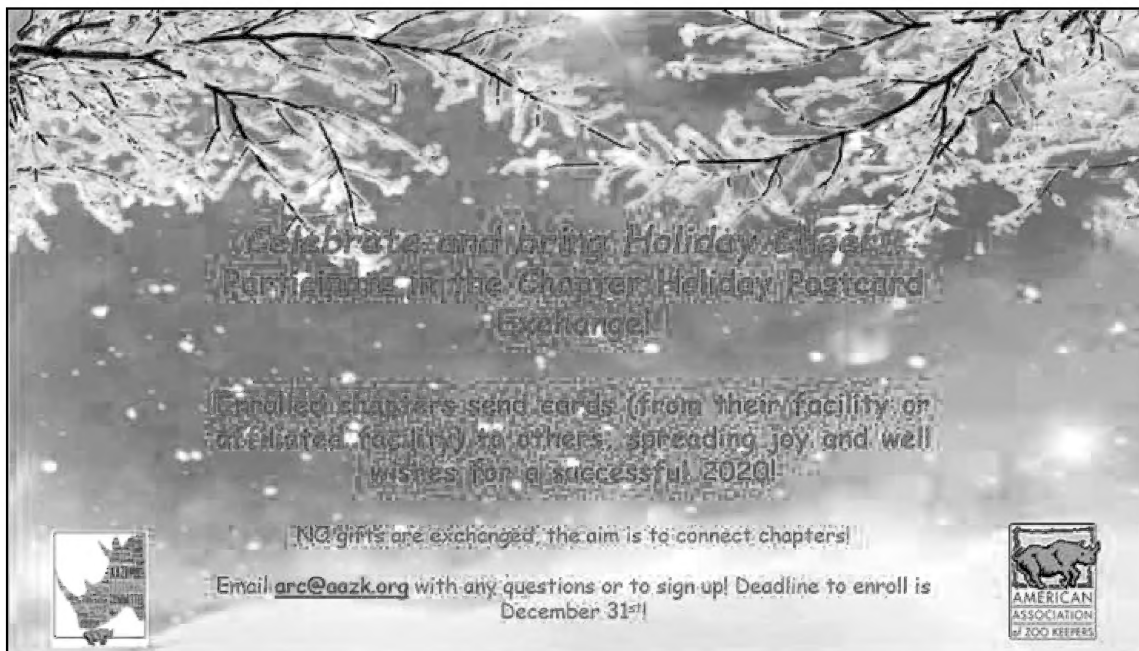
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